Expert Report of Daniel P. Kessler, J.D., Ph.D.

# Appendix E: Association between Per Capita Shipments and Opioid Mortality Rate
## Using Year and County Fixed Effects
## 2006–2018

| | Prescription Opioid Mortality Rate per 100,000 | Illicit Mortality Rate per 100,000 |
|---|---|---|
| **Shipment per capital per day** | | |
| **Coefficient** | **0.3655\*\*\*** | **-0.1309** |
| Standard Error | (0.1228) | (0.1527) |
| T-stat | 2.9767 | -0.8569 |
| P-Value | (0.0029) | (0.3916) |
| **1-year Lagged Shipment** | | |
| **Coefficient** | **0.1711\*\*\*** | **0.0054** |
| Standard Error | (0.0539) | (0.0831) |
| T-stat | 3.1752 | 0.0651 |
| P-Value | (0.0015) | (0.9481) |
| **2-year Lagged Shipment** | | |
| **Coefficient** | **0.1239\*\*\*** | **-0.1075** |
| Standard Error | (0.0372) | (0.0707) |
| T-stat | 3.3263 | -1.5199 |
| P-Value | (0.0009) | (0.1287) |
| **3-year Lagged Shipment** | | |
| **Coefficient** | **0.0741\*** | **-0.0405** |
| Standard Error | (0.0388) | (0.0783) |
| T-stat | 1.9106 | -0.5177 |
| P-Value | (0.0562) | (0.6047) |
| **4-year Lagged Shipment** | | |
| **Coefficient** | **0.0388** | **-0.2881\*\*** |
| Standard Error | (0.0478) | (0.1244) |
| T-stat | 0.8112 | -2.3162 |
| P-Value | (0.4174) | (0.0206) |
| **5-year Lagged Shipment** | | |
| **Coefficient** | **-0.0371** | **-0.1578\*\*** |
| Standard Error | (0.0455) | (0.0750) |
| T-stat | -0.8158 | -2.1049 |
| P-Value | (0.4147) | (0.0354) |
| **6-year Lagged Shipment** | | |
| **Coefficient** | **-0.0511** | **0.0474** |
| Standard Error | (0.0359) | (0.1269) |
| T-stat | -1.4245 | 0.3738 |
| P-Value | (0.1544) | (0.7086) |
| **7-year Lagged Shipment** | | |
| **Coefficient** | **0.0343** | **0.0292** |
| Standard Error | (0.0390) | (0.1578) |
| T-stat | 0.8799 | 0.1850 |
| P-Value | (0.3790) | (0.8532) |

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|---|---|---|
| **8-year Lagged Shipment** | | |
| **Coefficient** | **0.0365** | **0.4625*** |
| Standard Error | (0.0960) | (0.2486) |
| T-stat | 0.3801 | 1.8604 |
| P-Value | (0.7039) | (0.0629) |
| **9-year Lagged Shipment** | | |
| **Coefficient** | **-0.1034** | **0.6144**** |
| Standard Error | (0.1000) | (0.2449) |
| T-stat | -1.0336 | 2.5089 |
| P-Value | (0.3014) | (0.0122) |
| **Census Population (Thousands)** | | |
| **Coefficient** | **-0.0018**** | **-0.0086***** |
| Standard Error | (0.0009) | (0.0028) |
| T-stat | -2.0802 | -3.0722 |
| P-Value | (0.0376) | (0.0021) |
| **Percent Male** | | |
| **Coefficient** | **19.7771*** | **140.6639***** |
| Standard Error | (10.7253) | (27.0458) |
| T-stat | 1.8440 | 5.2009 |
| P-Value | (0.0653) | (0.0000) |
| **Percent Under 15** | | |
| **Coefficient** | **1.9884** | **68.7130**** |
| Standard Error | (10.5814) | (26.7466) |
| T-stat | 0.1879 | 2.5690 |
| P-Value | (0.8510) | (0.0103) |
| **Percent 15 to 29** | | |
| **Coefficient** | **4.6992** | **20.0235** |
| Standard Error | (9.1638) | (20.1924) |
| T-stat | 0.5128 | 0.9916 |
| P-Value | (0.6081) | (0.3215) |
| **Percent 30 to 44** | | |
| **Coefficient** | **-7.2145** | **-127.5933***** |
| Standard Error | (8.9669) | (20.2319) |
| T-stat | -0.8046 | -6.3066 |
| P-Value | (0.4211) | (0.0000) |
| **Percent 45 to 64** | | |
| **Coefficient** | **15.5049** | **24.8568** |
| Standard Error | (9.7262) | (17.8339) |
| T-stat | 1.5941 | 1.3938 |
| P-Value | (0.1110) | (0.1635) |

# Appendix E: Association between Per Capita Shipments and Opioid Mortality Rate
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## 2006–2018

| | Prescription Opioid Mortality Rate per 100,000 | Illicit Mortality Rate per 100,000 |
|---|---|---|
| **Percent White** | | |
| **Coefficient** | **7.3367** | **32.7329**** |
| Standard Error | (5.8401) | (13.2860) |
| T-stat | 1.2563 | 2.4637 |
| P-Value | (0.2091) | (0.0138) |
| **Percent Black** | | |
| **Coefficient** | **7.0053** | **31.6020** |
| Standard Error | (8.3777) | (21.7382) |
| T-stat | 0.8362 | 1.4538 |
| P-Value | (0.4031) | (0.1461) |
| **Percent Hispanic** | | |
| **Coefficient** | **-10.5118**** | **1.3854** |
| Standard Error | (4.5670) | (14.2592) |
| T-stat | -2.3017 | 0.0972 |
| P-Value | (0.0214) | (0.9226) |
| **Percent Less High School** | | |
| **Coefficient** | **3.5395** | **-55.5602***** |
| Standard Error | (5.2808) | (13.3119) |
| T-stat | 0.6702 | -4.1737 |
| P-Value | (0.5028) | (0.0000) |
| **Percent High School** | | |
| **Coefficient** | **-1.1437** | **-75.7808***** |
| Standard Error | (4.2398) | (13.1344) |
| T-stat | -0.2698 | -5.7696 |
| P-Value | (0.7874) | (0.0000) |
| **Percent Some College** | | |
| **Coefficient** | **6.0952** | **-18.1217** |
| Standard Error | (4.9731) | (11.4548) |
| T-stat | 1.2256 | -1.5820 |
| P-Value | (0.2204) | (0.1138) |
| **Employment Ratio** | | |
| **Coefficient** | **0.8010** | **13.6336***** |
| Standard Error | (1.8395) | (4.9397) |
| T-stat | 0.4355 | 2.7600 |
| P-Value | (0.6633) | (0.0058) |
| **Percent Unemployed** | | |
| **Coefficient** | **0.0752**** | **0.0863** |
| Standard Error | (0.0353) | (0.1175) |
| T-stat | 2.1301 | 0.7343 |
| P-Value | (0.0333) | (0.4628) |

# Appendix E: Association between Per Capita Shipments and Opioid Mortality Rate
## Using Year and County Fixed Effects
## 2006–2018

| | Prescription Opioid Mortality Rate per 100,000 | Illicit Mortality Rate per 100,000 |
|---|---|---|
| **Percent Urban** | | |
| **Coefficient** | **-1.9742** | **-28.7791***** |
| Standard Error | (7.0821) | (10.7333) |
| T-stat | -0.2788 | -2.6813 |
| P-Value | (0.7805) | (0.0074) |
| **Poverty Rate** | | |
| **Coefficient** | **0.4029** | **45.5082***** |
| Standard Error | (2.9731) | (7.7236) |
| T-stat | 0.1355 | 5.8921 |
| P-Value | (0.8922) | (0.0000) |
| **Median Houshold Income (Thousands)** | | |
| **Coefficient** | **0.0214**** | **-0.1252***** |
| Standard Error | (0.0109) | (0.0405) |
| T-stat | 1.9642 | -3.0873 |
| P-Value | (0.0496) | (0.0020) |
| **Percent Ag/M/Const/Util** | | |
| **Coefficient** | **7.2682** | **-0.4888** |
| Standard Error | (5.2412) | (10.6362) |
| T-stat | 1.3868 | -0.0460 |
| P-Value | (0.1656) | (0.9634) |
| **Percent Manufacturing** | | |
| **Coefficient** | **3.3987** | **-3.5114** |
| Standard Error | (4.5389) | (10.3318) |
| T-stat | 0.7488 | -0.3399 |
| P-Value | (0.4540) | (0.7340) |
| **Percent Retail/Transportation** | | |
| **Coefficient** | **4.4846** | **-3.6840** |
| Standard Error | (4.7228) | (11.3676) |
| T-stat | 0.9496 | -0.3241 |
| P-Value | (0.3424) | (0.7459) |
| **Percent Financial and Professional Services** | | |
| **Coefficient** | **3.1920** | **-1.0196** |
| Standard Error | (4.4096) | (10.3028) |
| T-stat | 0.7239 | -0.0990 |
| P-Value | (0.4692) | (0.9212) |
| **Percent Health Care and Education Services** | | |
| **Coefficient** | **5.5182** | **1.6216** |
| Standard Error | (4.6208) | (10.0018) |
| T-stat | 1.1942 | 0.1621 |
| P-Value | (0.2325) | (0.8712) |

# Appendix E: Association between Per Capita Shipments and Opioid Mortality Rate
## Using Year and County Fixed Effects
## 2006–2018

| | Prescription Opioid Mortality Rate per 100,000 | Illicit Mortality Rate per 100,000 |
|---|---|---|
| **Percent Repair, Maintenance, and Other Services** | | |
| **Coefficient** | **7.9072** | **0.5110** |
| Standard Error | (5.3669) | (12.6459) |
| T-stat | 1.4733 | 0.0404 |
| P-Value | (0.1408) | (0.9678) |
| **Percent in Management, business, science, and arts occupations** | | |
| **Coefficient** | **-2.6012** | **-2.0858** |
| Standard Error | (4.7835) | (10.6514) |
| T-stat | -0.5438 | -0.1958 |
| P-Value | (0.5866) | (0.8448) |
| **Percent in Service occupations** | | |
| **Coefficient** | **-0.1166** | **-21.5386*** |
| Standard Error | (4.8809) | (12.1725) |
| T-stat | -0.0239 | -1.7695 |
| P-Value | (0.9809) | (0.0769) |
| **Percent in Sales and office occupation** | | |
| **Coefficient** | **-2.6350** | **-33.7823*** |
| Standard Error | (5.1128) | (11.5775) |
| T-stat | -0.5154 | -2.9179 |
| P-Value | (0.6063) | (0.0036) |
| **Percent in Natural resources, construction, and maintenance occupations** | | |
| **Coefficient** | **3.5723** | **3.3925** |
| Standard Error | (4.7642) | (12.7387) |
| T-stat | 0.7498 | 0.2663 |
| P-Value | (0.4534) | (0.7900) |
| **Total M.D.'s/Pop** | | |
| **Coefficient** | **43.2056** | **1,726.5751*** |
| Standard Error | (127.7326) | (655.8983) |
| T-stat | 0.3383 | 2.6324 |
| P-Value | (0.7352) | (0.0085) |
| **Total Active Dentists/Pop** | | |
| **Coefficient** | **547.9230** | **-3,092.3762** |
| Standard Error | (657.2654) | (1,933.4551) |
| T-stat | 0.8336 | -1.5994 |
| P-Value | (0.4046) | (0.1099) |
| **Eligible for Medicare/Pop** | | |
| **Coefficient** | **-10.3405** | **-12.7291** |
| Standard Error | (6.5337) | (16.0536) |
| T-stat | -1.5826 | -0.7929 |
| P-Value | (0.1136) | (0.4279) |

# Appendix E: Association between Per Capita Shipments and Opioid Mortality Rate
## Using Year and County Fixed Effects
## 2006–2018

| | Prescription Opioid Mortality Rate per 100,000 | Illicit Mortality Rate per 100,000 |
|---|---|---|
| **Medicare Enrollment, aged and disabled/Pop** | | |
| **Coefficient** | **-0.4728** | **-11.8313\*\*** |
| Standard Error | (2.7274) | (4.9852) |
| T-stat | -0.1733 | -2.3733 |
| P-Value | (0.8624) | (0.0177) |
| **Hospices/Pop** | | |
| **Coefficient** | **10,674.6719\*\*** | **-20,063.0000\*** |
| Standard Error | (5,307.5361) | (11,586.6963) |
| T-stat | 2.0112 | -1.7316 |
| P-Value | (0.0444) | (0.0835) |
| **Veteran Population Estimate/Pop** | | |
| **Coefficient** | **16.7728\*\*\*** | **-28.0249\*\*** |
| Standard Error | (5.3507) | (14.1182) |
| T-stat | 3.1347 | -1.9850 |
| P-Value | (0.0017) | (0.0472) |
| **Hospital Beds/Pop** | | |
| **Coefficient** | **-125.9063** | **459.2236** |
| Standard Error | (140.8684) | (350.3253) |
| T-stat | -0.8938 | 1.3108 |
| P-Value | (0.3715) | (0.1900) |
| **Short Term General Hospital Beds/Pop** | | |
| **Coefficient** | **87.5784** | **-227.8284** |
| Standard Error | (142.3184) | (348.2509) |
| T-stat | 0.6154 | -0.6542 |
| P-Value | (0.5384) | (0.5130) |
| **Long Term General Hospital Beds/Pop** | | |
| **Coefficient** | **127.5610** | **-190.1050** |
| Standard Error | (137.1219) | (296.6267) |
| T-stat | 0.9303 | -0.6409 |
| P-Value | (0.3523) | (0.5217) |
| **Percent Disabled** | | |
| **Coefficient** | **3.5276** | **22.9251\*\*** |
| Standard Error | (3.9092) | (9.8112) |
| T-stat | 0.9024 | 2.3366 |
| P-Value | (0.3669) | (0.0195) |
| **Percent Uninsured** | | |
| **Coefficient** | **-0.0011** | **0.1826\*\*\*** |
| Standard Error | (0.0176) | (0.0514) |
| T-stat | -0.0627 | 3.5516 |
| P-Value | (0.9500) | (0.0004) |

# Appendix E: Association between Per Capita Shipments and Opioid Mortality Rate
## Using Year and County Fixed Effects
## 2006–2018

| | Prescription Opioid Mortality Rate per 100,000 | Illicit Mortality Rate per 100,000 |
|---|---|---|
| **Percent Binge Drinking** | | |
| **Coefficient** | **-2.5629** | **-7.3376** |
| Standard Error | (1.7894) | (5.7526) |
| T-stat | -1.4322 | -1.2755 |
| P-Value | (0.1522) | (0.2022) |
| **Percent Poor or Fair Health** | | |
| **Coefficient** | **-1.8449** | **9.1236** |
| Standard Error | (2.4381) | (6.9585) |
| T-stat | -0.7567 | 1.3111 |
| P-Value | (0.4493) | (0.1899) |
| **Percent Poor Physical Health Days** | | |
| **Coefficient** | **0.1016** | **0.6224** |
| Standard Error | (0.1324) | (0.3860) |
| T-stat | 0.7678 | 1.6125 |
| P-Value | (0.4427) | (0.1070) |
| **Percent Poor Mental Health Days** | | |
| **Coefficient** | **0.1374** | **-0.4858** |
| Standard Error | (0.1165) | (0.3598) |
| T-stat | 1.1796 | -1.3500 |
| P-Value | (0.2383) | (0.1771) |
| **Percent Adult Smoking** | | |
| **Coefficient** | **3.2639** | **-7.0760** |
| Standard Error | (2.0713) | (5.2197) |
| T-stat | 1.5758 | -1.3556 |
| P-Value | (0.1152) | (0.1753) |
| **Percent Diabetes** | | |
| **Coefficient** | **-0.0256** | **-0.1809**\*\* |
| Standard Error | (0.0318) | (0.0836) |
| T-stat | -0.8044 | -2.1632 |
| P-Value | (0.4213) | (0.0306) |
| **Percent Obesity** | | |
| **Coefficient** | **0.0064** | **0.0617**\* |
| Standard Error | (0.0122) | (0.0359) |
| T-stat | 0.5220 | 1.7177 |
| P-Value | (0.6017) | (0.0860) |
| **Cancer Deaths per 100,000** | | |
| **Coefficient** | **0.0002** | **-0.0106**\*\*\* |
| Standard Error | (0.0012) | (0.0030) |
| T-stat | 0.1769 | -3.4873 |
| P-Value | (0.8596) | (0.0005) |

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## Using Year and County Fixed Effects
## 2006–2018

| | Prescription Opioid Mortality Rate per 100,000 | Illicit Mortality Rate per 100,000 |
|---|---|---|
| **Constant** | | |
| **Coefficient** | **-21.0981** | **-22.6620** |
| Standard Error | (14.5614) | (27.7734) |
| T-stat | -1.4489 | -0.8160 |
| P-Value | (0.1475) | (0.4146) |
| | | |
| **Sum of Shipment Variables** | 0.652 | 0.434 |
| Standard Error | 0.200 | 0.408 |
| Lower Bound (95% CI) | 0.261 | -0.366 |
| Upper Bound (95% CI) | 1.044 | 1.234 |
| T-Statistic | 3.267 | 1.065 |
| P-Value | 0.00110 | 0.287 |
| | | |
| **Observations** | 24,621 | 24,621 |
| **R-squared** | 0.6444 | 0.6781 |
| **Adjusted R-squared** | 0.602 | 0.640 |

Source: 1997–2018 US Census Data; CDC Restricted Mortality; ARCOS; American Community Survey; County Business Patterns (CBP) Datasets; BRFSS; AHRF; CDC WONDER.

Note:
[1]  Shipments are defined as shipment per capital per day.  Opioid shipments include Fentanyl, Hydrocodone, Hydromorphone, Morphine, Oxycodone, Oxymorphone, Methadone, and Tapentadol.
[2]  A *** indicates a p-value of <0.01; ** indicates a p-value of <0.05; and a * indicates a p-value of <0.1.
[3]  Mortality rate is mortality per 100,000 persons.  Illicit Mortality are the deaths with multiple cause of death codes that include Opium, Heroin, Fentanyl, and Unkown Opioids (T40.0, T40.1, T40.4, and T40.6 based on ICD-10 Codes).  Prescription Mortality are the deaths with multiple cause of death codes that include other prescription opioids (T40.2 and T40.3 based on ICD-10 Codes) but not any Illicit Mortality codes (T40.0, T40.1, T40.4, and T40.6 based on ICD-10 Codes).
[4]  All regressions are population-weighted.  Standard errors are clustered at the county level.